Methane and nitrous oxide emission from rice field under long-term fertilization

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Introduction

Rice is an important crop in China, both as major food source, and an export commodity. There are many factors which affect CH4 and N2O emission from rice fields. A rice experiment in the Hunan province of China with two seeding dates and 4 fertilizer treatments began in 1980. The fertilizer treatments consisted of no fertilizer, inorganic fertilizer only, or a combination of inorganic fertilizer and an organic amendment, either rice straw or hog manure. The purpose of this study is to determine the effect of these fertilizer treatments on greenhouse gas (GHG) emissions.

Materials and methods

Four long-term fertilization treatments were selected from 2004 to observe GHG emissions. They are 1) NPKS (NPK + straw); 2) CK (no fertilizer); 3) NPK; and 4) NKM (NK + hog manure). The fertilizers applied were Urea (N), P2O5 (P), K2O (K). The early rice treatment received 75 kg ha-1 N initially and was top dressed with an additional 75 kg ha-1 N. The late rice received 90 kg ha-1 N and was top dressed with another 90 kg ha-1 N. Rates of P and K were applied at 45 kg ha-1 and 120 kg ha-1 respectively. All fertilizers are applied as kg ha-1 of product. Decomposed hog manure from a biogas container (Marsh gas-methane) which is used to collect methane gas from the fermentation process was applied at a rate of 15000 kg ha-1 to the NKM treatment. The NPKS treatment received rice straw at 2625 kg ha-1.

There is one plot for each treatment, and three repetitions in one plot. We installed one sampling chamber for each repetition. In the entire experimental period from the sowing of early rice to the harvest of late rice, GHG sample were taken manually once every three days, usually 9~10 am. Concentration of GHG was analyzed by Agilent 6890N GC.

The flux of GHG was calculated by the following formula:

$$F=\rho\cdot h\cdot dC/dt\cdot 273/(273+T)$$

Where:

F - GHG Flux (CH4:mg·m-2·h-1, N2O:μg·m-2·h-1),

ρ- Density of GHG in standard conditions
(CH_4: 0.717kg·m-3, N_2O: 1.97kg·m-3)
h - Height of chamber (m),
dC/dt - Rate of GHG change in chamber,
T - Average chamber temperature during sampling.

Results and discussion

Seasonal variation of CH4 flux from rice field

There is only one big CH4 flux peak during the entire rice growing season (Fig. 1). Most of CH4 fluxes were emitted before drainage, after that, there was only a little CH4 emission.

Seasonal variation of N2O flux from rice field

The seasonal variation of N2O flux from rice field was distinct with CH4 (Fig. 2). There were several N2O flux peaks in the growing season, but the largest one occurs after drainage.

Effect of long-term fertilization on GHG emission from rice field

The rank of CH4 average flux in different fertilization treatments is: NPKS> NKM>CK>NPK (Fig. 3). The rank of N2O average flux in different treatments from early rice is: NPK>NKM>NPKS>CK, but from late rice is: NPKS>NPK>NKM>CK (Fig. 4).

Relationship between CH4 flux and soil temperature

In the range of 15～30℃, CH4 flux from rice field increased with the soil temperature at 10cm.

In the same temperature range, N2O flux from late rice field after drainage increasing with the soil temperature in 10cm (Fig. 5).

Relationship between CH4 flux and soil pH

In the range of pH5-5.8 and pH6.2-6.8, CH4 flux from rice field increasing with the soil pH,there is a linear relationship between CH4 flux and soil pH (Fig. 6). In the range of pH6.2-6.8, N2O flux from late rice field before drainage is increasing with the soil pH.

References

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Figure 1 Seasonal variation of CH_4 flux from rice field

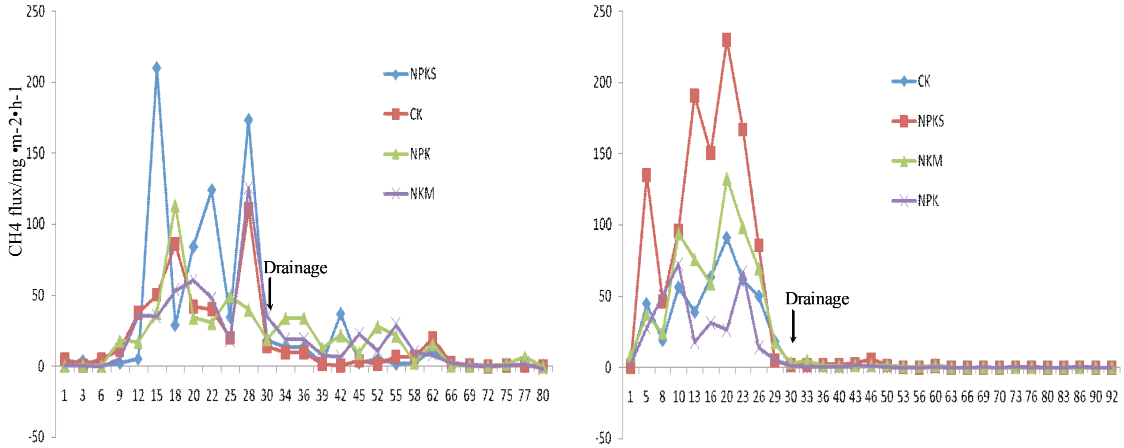

Figure 2 Seasonal variation of N_2O flux from rice field

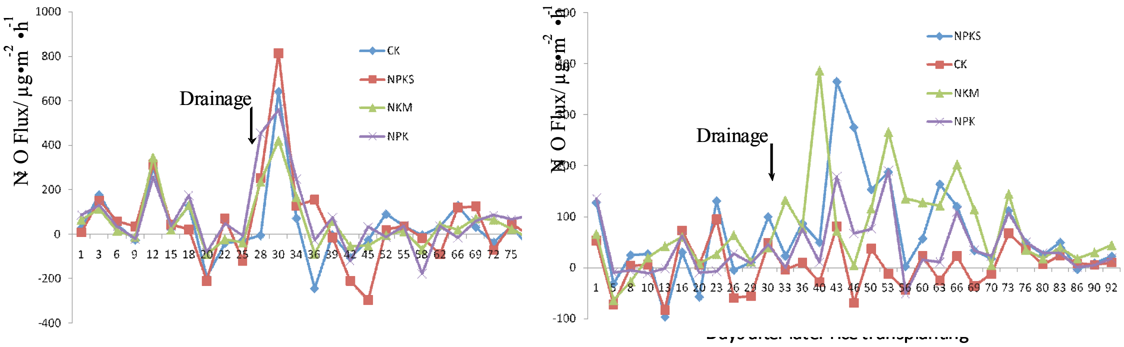

Figure 3. CH_4 flux from every long-term fertilization treatment

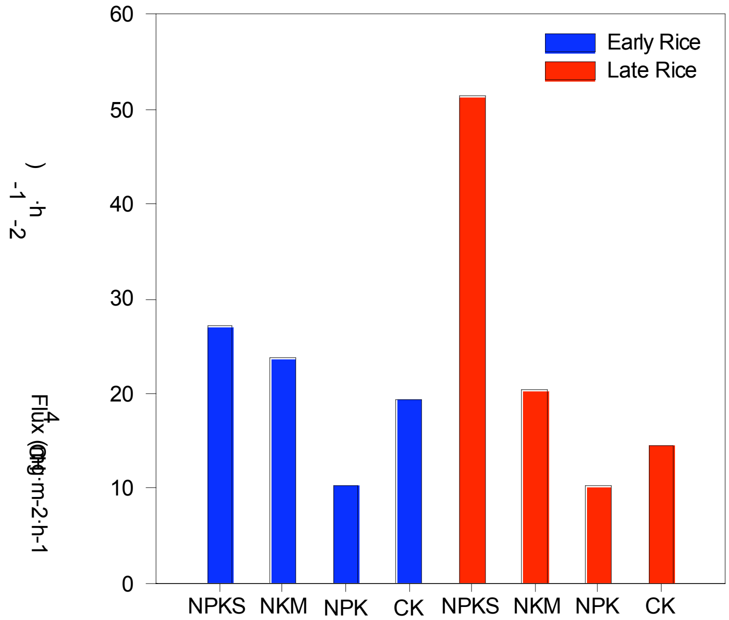

Figure 4. N_2O flux from every long-term fertilization treatment

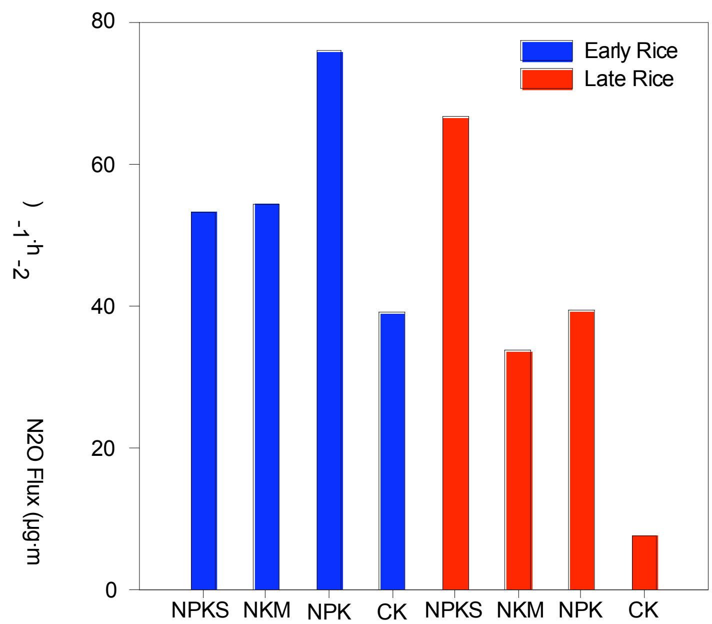

Figure 5. Relationship between CH_4 flux and soil temperature in 10cm depth

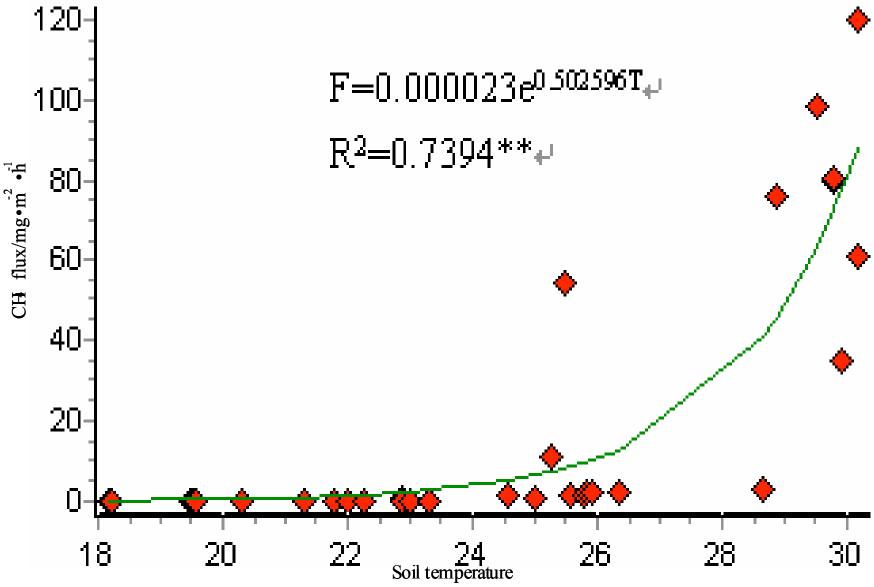

Figure 6. Relationship between CH_4 flux and soil pH